Soil Quality in Integrated Crop-Livestock Systems with Conservation and Conventional Tillage

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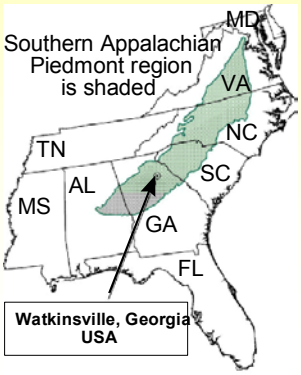

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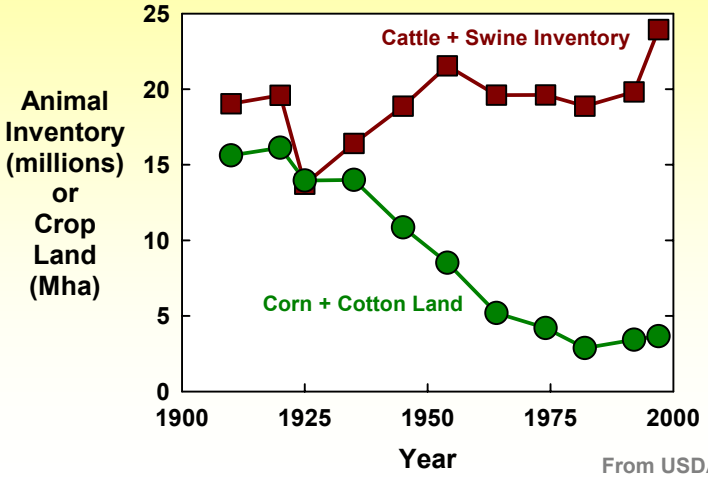
The last century of agriculture in Georgia



From USDA – National Agricultural Statistics Service

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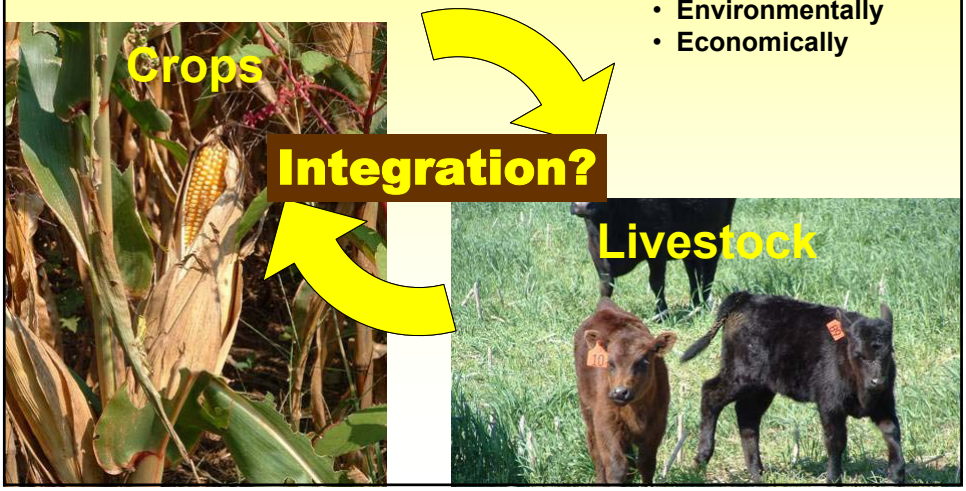
The future?

Integration has benefits:

- Agronomically
- Environmentally
- Economically

But what about soil compaction?



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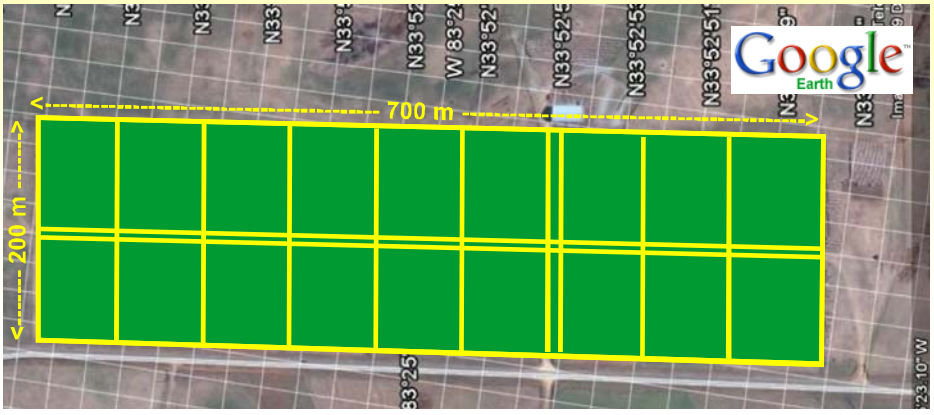
Experimental setup

Tall fescue grazing experiment for 20 years (1982-2001)
0.7-ha paddocks (n = 18)



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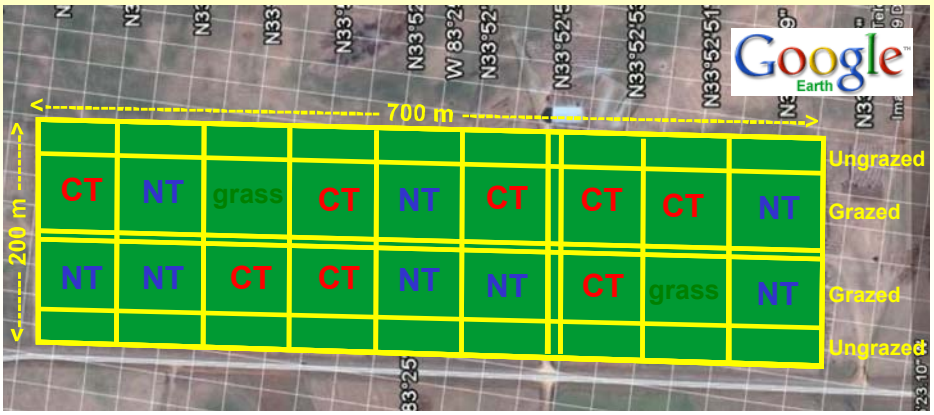
Experimental setup

Converted to cropping system experiment in 2002
0.5-ha grazed paddocks (n = 18) + 0.2 ha ungrazed controls (n = 18)



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Tillage approaches

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Cropping systems

Year	System 1	System 2
2002, 2003, 2004, 2005	Sorghum/rye	Pearl millet/wheat
	Renewable Agriculture and Food Systems (2007) 22:168-180	
2006, 2007, 2008	Corn/wheat–soybean/rye+clover [low N input]	Corn/wheat–soybean/rye+ryegrass [high N input]
2009	Pearl millet/wheat	Pearl millet/wheat

Both systems with 4 reps of CT and 4 reps of NT		
	Grazed components	
	Rye, corn stover, rye+clover, pearl millet	Pearl millet, corn stover, rye+ryegrass

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Cover crop management

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Soil responses

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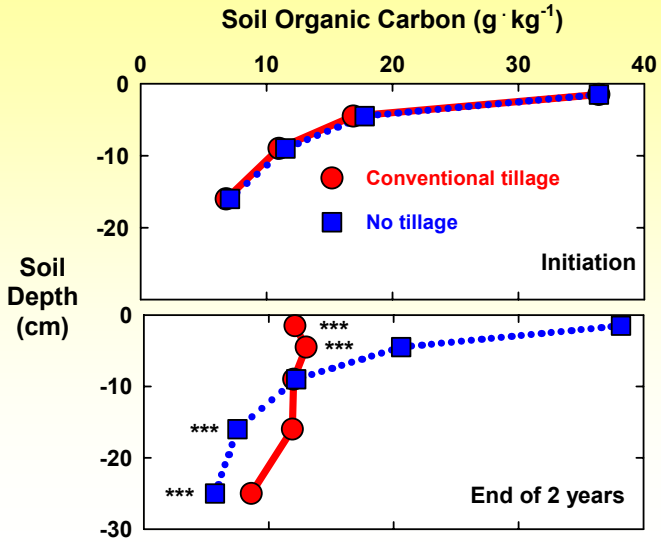
Soil organic C depth distribution

At initiation of this study, land was in long-term tall fescue pasture.

Land converted to cropping systems of wheat/pearl millet or sorghum/rye.



Franzluebbers and Stuedemann (2008) Soil Sci. Soc. Am. J. 72:613-625

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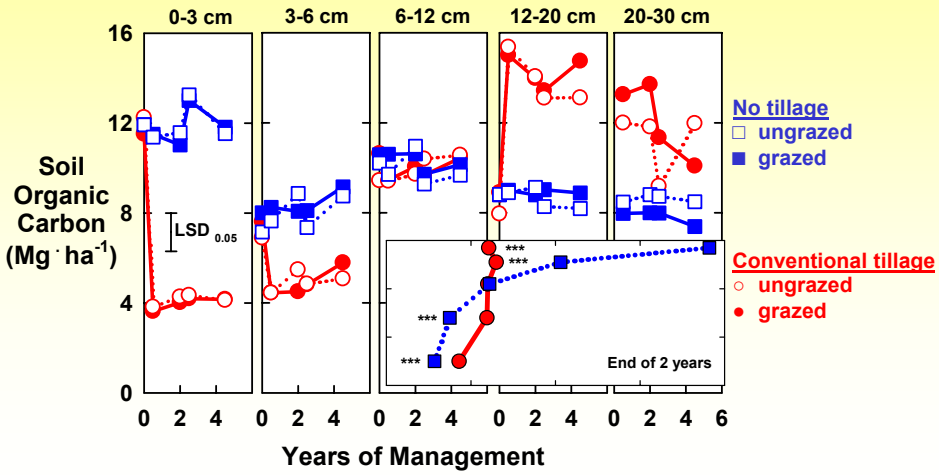
Change in soil organic C stock with time



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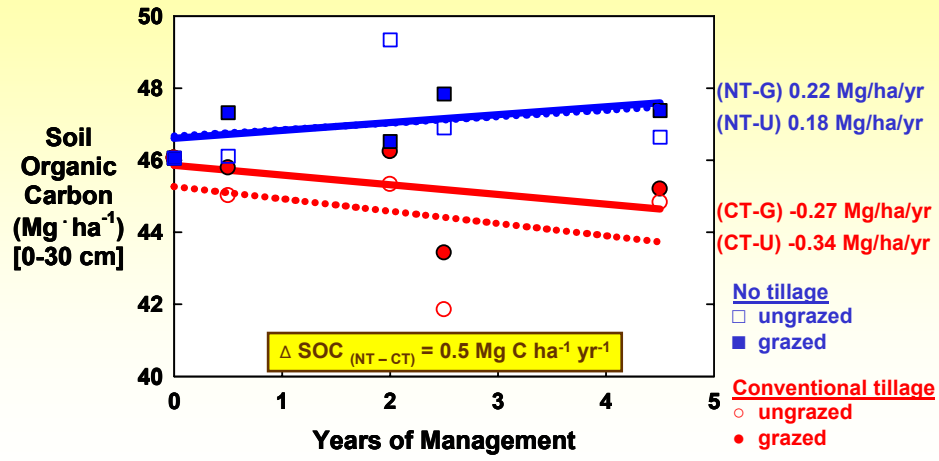

Franzluebbers and Stuedemann (2008) Soil Sci. Soc. Am. J. 72:613-625

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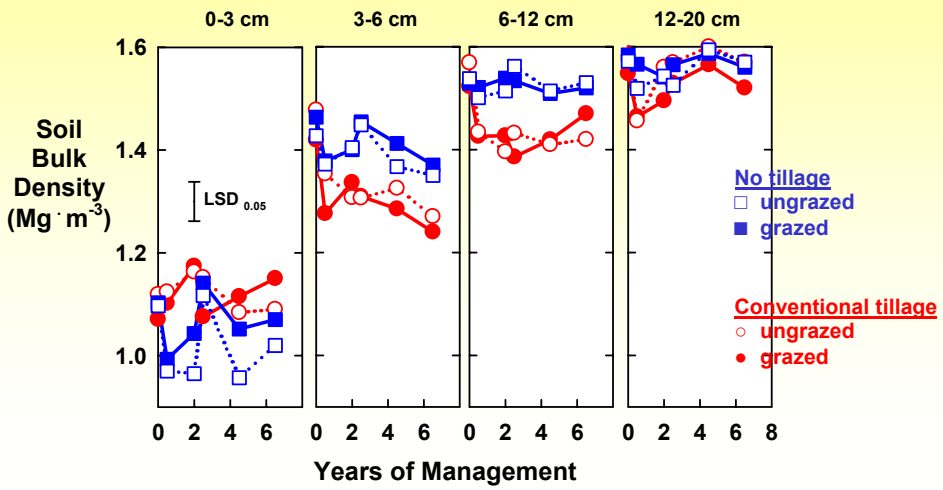
Soil bulk density



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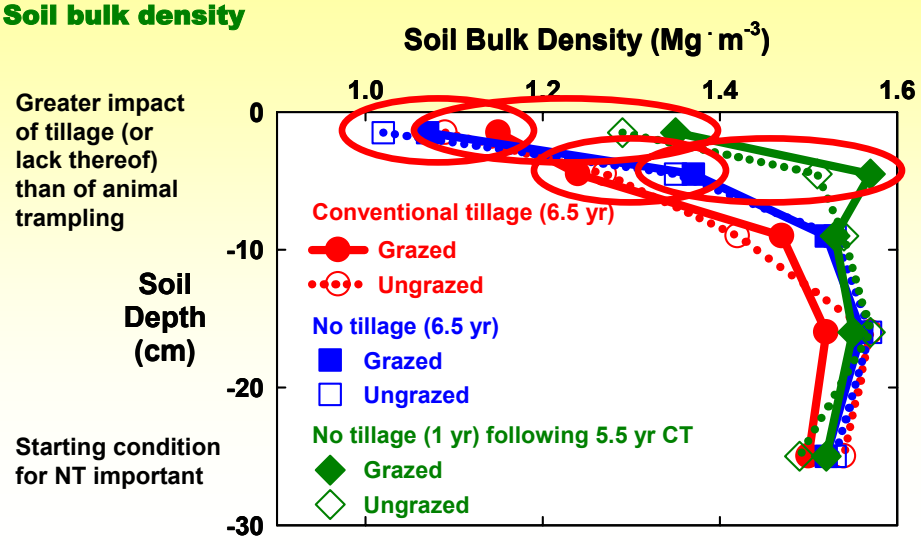
Soil bulk density



Greater impact of tillage (or lack thereof) than of animal trampling

Starting condition for NT important

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Soil penetration resistance

Tillage	Cover crop	Water content	Soil depth (cm)		
			0-10	10-20	20-30
		$m^3\ m^{-3}$	---------- Joules ----------		
Dry soil conditions (4 events in 2004 and 2005)					
CT	Grazed	0.12	119	246	290
CT	Ungrazed	0.11	84	261	337
NT	Grazed	0.12	151	248	296
NT	Ungrazed	0.12	139	313	394

NT > CT

Franzluebbers and Stuedemann (2008) Soil Till. Res. 100:141-153

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Soil penetration resistance

Tillage	Cover crop	Water content	Soil depth (cm)		
			0-10	10-20	20-30
		$m^3\ m^{-3}$	---------- Joules ----------		
Wet soil conditions (6 events in 2003, 2004 and 2005)					
CT	Grazed	0.20	104	115	124
CT	Ungrazed	0.20	62	111	118
NT	Grazed	0.22	102	133	133
NT	Ungrazed	0.22	90	131	137

NT > CT G > U NT > CT

Franzluebbers and Stuedemann (2008) Soil Till. Res. 100:141-153

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Single-ring water infiltration

Tillage	Cover crop	Water content	Macropore filling	Infiltration rate
		$m^3\ m^{-3}$	mm	mm min^{-1}
Wet soil conditions (3 events in 2003, 2004, and 2005)				
		0.11	*27*	*7.2*
CT	Grazed	0.18	24	4.0
CT	Ungrazed	0.19	29	6.1
NT	Grazed	0.20	12	3.1
NT	Ungrazed	0.21	26	6.5

U > G

Franzluebbers and Stuedemann (2008) Soil Till. Res. 100:141-153

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Soil biochemical C and N fractions

Tillage	Cover crop	Particulate organic C	Microbial biomass C	Mineralizable	
				C	N
		----- Mg ha^{-1} -----		----- kg ha^{-1} 24 d^{-1} -----	
Average from 0.5, 2.0, and 2.5 yr after initiation					
CT	Grazed	2.2	0.44	383	24
CT	Ungrazed	2.3	0.46	444	24
NT	Grazed	7.3	0.82	724	57
NT	Ungrazed	7.5	0.77	681	62
		NT > CT	NT > CT *	NT > CT **	NT > CT

Franzluebbers and Stuedemann (2008) Soil Sci. Soc. Am. J. 72:613-625

Implications

1. Cover crops (winter or summer) can provide high-quality forage and increase economic return and farm diversity, but farmers have been reluctant to take this advantage due to perceived "compaction" caused by animal trampling

2. Rotation of crops following long-term pasture was highly effective in limiting (or avoiding) compaction with grazing cattle by creating a SOM-enriched surface condition that was preserved for many years with subsequent conservation-tillage management

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Implications

3. Grazing of cover crops does indeed compact soil, but not to the detrimental levels often perceived:
   - ✓ Grazing had little effect on bulk density under either tillage system – much less than lack of tillage when switching from conventional to no tillage
   - ✓ Grazing had essentially no effect on soil organic C content and depth distribution
   - ✓ Grazing increased penetration resistance of the surface 10 cm of soil – discernable only under wet soil conditions
   - ✓ Grazing reduced single-ring water infiltration – discernable only under wet soil conditions
   - ✓ Grazing actually improved surface-soil biochemical properties under long-term conservation tillage

Presentation at the 18th International Soil Tillage Research Organization Triennial meeting in Izmir TURKEY, 15-19 June 2009